

CLAIMS

What is claimed is:

- 1 1. A system for providing integrated control of multiple well tools, comprising:
2
3 at least three hydraulically controlled well tool devices; and
4 a pair of hydraulic control lines coupled to the at least three hydraulically
5 controlled well tool devices, wherein the at least three hydraulically controlled
6 well tool devices are independently controllable via application of at least one
7 unique pressure level in at least one of the pair of hydraulic control lines.
- 1 2. The system as recited in claim 1, wherein the at least three hydraulically
2 controlled well tool devices comprise six hydraulically controlled well tool
3 devices.
- 1 3. The system as recited in claim 2, wherein a first group of three hydraulically
2 controlled well tool devices are controlled by unique pressure levels in a first
3 hydraulic control line of the pair of hydraulic control lines, and a second group of
4 three hydraulically controlled well tool devices are controlled by unique pressure
5 levels in a second hydraulic control line of the pair of hydraulic control lines.
- 1 4. The system as recited in claim 1, wherein each hydraulically controlled well tool
2 device comprises a decoder hydraulically coupled to a corresponding
3 hydraulically controlled well tool, each decoder comprising a main valve that
4 remains open through a predetermined pressure range applied to one of the pair of
5 control lines, the other of the pair of control lines being placed in direct hydraulic
6 communication with the hydraulically controlled well tool when the main valve is
7 open.

- 1 5. The system as recited in claim 4, wherein the predetermined pressure range is
2 unique to each decoder controlled by a given hydraulic control line of the pair of
3 hydraulic control lines.
- 1 6. The system as recited in claim 5, wherein the predetermined pressure ranges are
2 established by a plurality of unique springs.
- 1 7. The system as recited in claim 4, wherein a plurality of the decoders each
2 comprises an accumulator and an accumulator valve to establish a reference
3 pressure with respect to the main valve.
- 1 8. The system as recited in claim 4, wherein a plurality of the decoders each
2 comprises a filling valve disposed in parallel to the main valve to equalize any
3 atmospheric pressure trapped in the corresponding hydraulically controlled well
4 tool.
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1 9. The system as recited in claim 4, wherein at least four decoders are connected to
2 at least four hydraulically controlled well tools, and the opening of the main valve
3 in 50 percent of the at least four decoders is controlled by a first of the pair of
4 control lines and the opening of the main valve in the other 50 percent of the at
5 least four decoders is controlled by a second of the pair of control lines.
- 1 10. The system as recited in claim 1, wherein the at least one unique pressure level
2 comprises two unique pressure levels.
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- 1 11. The system as recited in claim 1, wherein the at least one unique pressure level
2 comprises three unique pressure levels.
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- 1 12. A method of controlling downhole tools, comprising:
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3 connecting at least three downhole tools to at least three corresponding
4 main valves that enable selective fluid flow to the at least three downhole tools;

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6 using a first hydraulic line to selectively open any of the at least three
7 corresponding main valves and a second hydraulic line to provide hydraulic input
8 to any of the at least three downhole tools upon opening of the corresponding
9 main valve; and

10
11 applying pressure at a unique pressure range within the first hydraulic line
12 to open a specific corresponding main valve.

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1 13. The method as recited in claim 12, wherein applying pressure comprises applying
2 pressure within one of at least two unique pressure ranges.

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14. The system as recited in claim 12, wherein applying pressure comprises applying
pressure at one of at least three unique pressure ranges.

1 15. The method as recited in claim 14, further comprising locating each
2 corresponding main valve in a decoder in which a biasing device is used to bias
3 the valve against the pressure applied by the first hydraulic line.

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1 16. The method as recited in claim 15, further comprising deploying an accumulator
2 in each decoder to create a reference pressure acting against the main valve.

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1 17. The method as recited in claim 14, further comprising:

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3 coupling additional downhole tools to additional corresponding main
4 valves;

6 selectively opening the additional corresponding main valves via the
7 second hydraulic line; and

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9 providing hydraulic input to the additional downhole tools through the
10 first hydraulic line.

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1 18. The method as recited in claim 17, further comprising locating all of the
2 additional corresponding main valves downstream from the at least three
3 corresponding main valves along the first and the second hydraulic control lines.

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1 19. The method as recited in claim 17, further comprising locating the additional
2 corresponding main valves in an alternating arrangement with the at least three
3 corresponding main valves along the first and the second hydraulic control lines.

1 20. A system of controllable well tools, comprising:

2
3 a plurality of downhole well tool components; and

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5 a plurality of fluid control lines, the number of downhole well tool
6 components being at least one more than the number of fluid control lines,
7 wherein the downhole well tool components may be individually controlled by
8 applying pressure in at least one of the fluid control lines at a level within a
9 predetermined pressure range associated with the individual downhole well tool
10 component.

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1 21. The system as recited in claim 20, wherein the plurality of fluid control lines
2 comprises two control lines, and the plurality of downhole well tool components
3 comprises at least four downhole tools.

- 1 22. The system as recited in claim 20, wherein the plurality of fluid control lines
2 comprises three control lines, and the plurality of downhole well tool components
3 comprises up to eighteen downhole tools.
- 1 23. The system as recited in claim 20, wherein each downhole well tool component
2 comprises a decoder having a spring-loaded valve that is hydraulically actuated,
3 the spring-loaded valve being designed to close if the pressure acting thereon
4 moves above or below a given pressure range.
- 1 24. The system as recited in claim 23, wherein a single decoder is associated with a
2 single hydraulically controlled well tool component of the plurality of downhole
3 well tool components.
- 1 25. The system as recited in claim 23, wherein a pair of decoders is associated with a
2 single hydraulically controlled well tool having at least two downhole well tool
3 components independently controlled.
- 1 26. The system as recited in claim 23, wherein each decoder comprises an
2 accumulator to establish a back reference pressure against the spring-loaded
3 valve.
- 1 27. The system as recited in claim 23, wherein each decoder comprises a filling valve
2 to equalize internal and external pressures.
- 1 28. The system as recited in claim 23, wherein the plurality of control lines comprises
2 a pair of control lines that crossover between a pair of decoders.
- 1 29. The system as recited in claim 23, wherein the plurality of control lines comprises
2 a pair of control lines that crossover between each decoder.

- 1 30. A system for controlling downhole tools, comprising:
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3 means for providing selective fluid flow via a fluid command line to at
4 least three fluid actuated downhole tools; and
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6 means for controlling independent actuation of each downhole tool by
7 pressurizing a fluid pilot line to within a predetermined pressure range associated
8 with the actuation of a specific downhole tool.
- 1 31. The system as recited in claim 30, wherein the means for providing comprises a
2 main valve.
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- 1 32. The system as recited in claim 31, wherein the means for controlling comprises a
2 first spring and a second spring position to resist movement of the valve, the
3 second spring being capable of exerting a greater spring force than the first spring.
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- 1 33. A system for providing integrated control of multiple well tools, comprising:
2
3 at least three hydraulically controlled well tool devices; and
4
5 a plurality of hydraulic control lines coupled to the at least three
6 hydraulically controlled well tool devices, wherein the at least three hydraulically
7 controlled well tool devices are independently controllable via sequential
8 application of pressure in the plurality of hydraulic control lines, further wherein
9 the number of hydraulically controlled well tools is greater than the number of
10 hydraulic control lines.
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- 1 34. The system as recited in claim 33, wherein the at least three hydraulically
2 controlled well tool devices comprise at least four hydraulically controlled well

3 tool devices, and the plurality of hydraulic control lines comprises three hydraulic
4 control lines.

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1 35. The system as recited in claim 33, wherein the at least three hydraulically
2 controlled well tool devices comprises six hydraulically controlled well tool
3 devices, and the plurality of hydraulic control lines comprises three hydraulic
4 control lines.

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1 36. The system as recited in claim 33, wherein each hydraulically controlled well tool
2 device comprises a decoder connected to a tool.

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1 37. A system for providing integrated control of multiple well tool components,
2 comprising:

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4 a plurality of decoders coupled to a plurality of well tool components;

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6 a first control line coupled to the plurality of decoders; and

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8 a second control line coupled to the plurality of decoders, wherein the first
9 and the second control lines each serve as a pilot line and a command line.

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1 38. The system as recited in claim 37, further comprising a crossover disposed
2 between two decoders of the plurality of decoders.

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1 39. The system as recited in claim 37, further comprising a plurality of crossovers
2 disposed between the plurality of decoders.

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1 40. The system as recited in claim 37, wherein the plurality of decoders comprises at
2 least four decoders.

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- 1 41. The system as recited in claim 37, further comprising a third control line that
2 serves as the pilot line and the command line.
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- 1 42. A method for providing integrated control of multiple well tool components,
2 comprising:
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4 connecting decoders to a plurality of hydraulically controlled well tool
5 components;
6
7 coupling a plurality of control lines to the decoders; and
8
9 utilizing each control line of the plurality of control lines as both a pilot
10 line for controlling a decoder and a command line for actuating a hydraulically
11 controlled well tool component.
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- 1 43. The method as recited in claim 42, wherein coupling comprises coupling two
2 control lines to the decoders.
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- 1 44. The method as recited in claim 42, further comprising controlling each decoder by
2 applying a unique predetermined pressure level in the pilot line.
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- 1 45. The method as recited in claim 44, wherein applying a unique predetermined
2 pressure level comprises applying a plurality of unique predetermined pressure
3 levels with each unique predetermined pressure level corresponding to the
4 actuation pressure required to actuate a specific decoder.
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46. The method as recited in claim 42, wherein coupling comprises coupling the
plurality of control lines to a greater number of decoders than the number of
control lines.